

# **A Proposal for the Development of a Comprehensive Monitoring Assessment and Research Program**

Developed for CALFED

By

The CMARP Steering Committee

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## **Executive Summary**

On December 20, 1997 the CALFED Policy Group requested staff from the United States Geological Survey (USGS), San Francisco Estuary Institute (SFEI), and the Interagency Ecological Program (IEP) work together to develop a proposal for a comprehensive monitoring assessment and research program (CMARP). The Policy Group requested the proposal include a recommended approach for program development and funding requirements. The proposal was to be brought back to the Policy Group within three months, and up to \$25,000 was authorized for expenditure to cover preparation costs.

This is the proposal, called the Stage I report, for development of a CMARP. The report was prepared by a steering committee consisting of staff from CALFED, IEP, USGS, and SFEI. The steering committee circulated a draft of this report to CALFED and agency staff, and to the CALFED Indicators Group and the ERPP strategic planning team. Steering committee representatives also briefed CALFED management, program managers, and the Ecosystem Roundtable. This report incorporates comments received from these reviews and briefings.

As background, the CALFED Bay/Delta Program is developing a long-term plan to restore ecosystem health and improve water management for beneficial uses of the Bay/Delta/Central Valley system. The program is to equally address the six program elements. The recommended program emerging from Stage II is expected to incorporate elements of existing monitoring and special studies programs such as the SFEI Regional Monitoring Program, the Department of Interior Comprehensive Assessment and Monitoring Program, the CALFED Operations Group Real-time Monitoring, the Vernalis Adaptive Management Program, and the IEP environmental monitoring activities.

Because there is incomplete knowledge of system functions and the effects of individual actions on populations and processes, the CALFED Bay/Delta Program is organized around the concept of adaptive management. Monitoring key system attributes (or indicators), completing focused research to obtain better understanding, and phasing implementation based on information gained are all central to the adaptive management process. The process will include numerous assessment and feedback loops so that management decisions are based on the best and most current information.

The steering committee recommends the following scope, approach, schedule, and funding for design of the comprehensive monitoring, assessment, and research plan.

- A final project report will be delivered within nine months from the date CALFED gives notice to proceed.

- The proposed budget is \$1,800,000.

- Specific tasks to be completed within nine months are:

- work with CALFED agencies and stakeholders to refine overall program goals and objectives;

- develop conceptual frameworks for understanding factors affecting the six common program elements of the Bay/Delta, its watershed, and as appropriate, the near-shore ocean;

- design a CMARP. The process leading to CMARP will include an inventory of existing monitoring and research activities, identification of data gaps (based in part on conceptual modeling described above), selection of monitoring elements, data management, interpretation, analysis and reporting, and establishment of a process for monitoring early implementation, including approved Category III projects;

- identify key research questions applicable to program actions, develop funding requirements, and develop a framework for a focused research program to answer these questions;

- propose an institutional framework necessary to implement the recommended CMARP.

A small steering committee consisting of CALFED, USGS, IEP, and SFEI program managers, staff and stakeholders will manage development of the CMARP. Much of the work will be completed by technical work teams and committees consisting of both agency staff and stakeholders. The steering committee will work closely with CALFED program managers, and expects to periodically brief the Bay/Delta Advisory Council, the Ecosystem Roundtable, and CALFED's Management and Policy Groups on progress toward the recommended plan. Final approval of any recommended plan will be through the CALFED process.

## Introduction

On November 24, 1997, the Interagency Ecological Program (IEP) proposed to the CALFED Policy Group that the IEP and the San Francisco Estuary Institute (SFEI) develop a comprehensive monitoring<sup>1\*</sup> assessment and research\* program for CALFED. The Policy Group approved this proposal and authorized \$25,000 for SFEI's participation. On December 19, the U.S. Geological Survey (USGS), a member agency of IEP, made a similar proposal to the Policy Group in response to a request by Bruce Babbitt, Secretary of the Interior<sup>2</sup>. As a result of the USGS proposal, the Policy Group requested that IEP, SFEI, and USGS work together to produce a final proposal for developing a comprehensive monitoring assessment and research program (CMARP) for CALFED (see Appendix B for memoranda describing the initial proposal and subsequent approval).

## The Issues

The CALFED Bay/Delta program is proposing substantial changes to many aspects of the Bay-Delta/Central Valley environment and water management system. In addition, many of the member agencies are currently charged with activities and programs directly affecting this system (e.g., SWRCB regulation of water rights, DWR/BOR export of water from the Delta, FWS/NMFS/DFG protection of threatened and endangered species, Department of Interior implementation of the Central Valley Project Improvement Act, etc.). Further, CALFED and its member agencies have adopted an adaptive management\* strategy as a process for implementing many of the proposed changes and ongoing activities (e.g., actions in the Ecosystem Restoration Program Plan, the Vernalis Adaptive Management Program, CALFED operations, and real-time monitoring).

In addition to implementation of the various actions and programs, CALFED and its member agencies are also responsible for the implementation of monitoring and applied research that provide the data and information necessary to evaluate the performance of completed actions and ongoing programs. For example, CALFED is developing a long-term

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<sup>1</sup> The CMARP Steering Committee has found that many terms are used by different parties to mean different things. The Committee has attempted to use certain terms consistently throughout this report and in our discussions with other parties. Appendix A is a glossary of these terms. The first occurrence of a term included in the glossary is denoted with an \*.

<sup>2</sup> In response to the request from Secretary Babbitt, the USGS produced a report entitled, *USGS CALFED Science Support Initiative*. Special Report (98-01). January 1998. U.S. Department of the Interior. U.S. Geological Survey. This report describes several recommended actions to strengthen the role of science in CALFED Bay-Delta rehabilitation efforts.

program that, based on adaptive management principles, has a maximum likelihood of achieving desired rehabilitation. The incremental approach of adaptive management (defining the problem(s), taking action, evaluating the benefits of the action, and modifying subsequent actions as necessary) requires extensive data collection, analysis, and interpretation, with feedback to resource managers and decision-makers. Equally important, CALFED will need to prepare for Congress, the California Legislature, government agencies, stakeholders, and the general public a "report card" describing its effectiveness in achieving the stated program goals. A CMARP is the most effective means of providing the information necessary for this reporting.

Many institutions, both within and outside of the CALFED partnership, are involved in monitoring and applied research that can contribute to the design and assessment of environmental rehabilitation programs (see Appendix C). The scope, coverage, and coordination of existing monitoring and applied research, however, are admittedly fragmentary. When viewed together, these programs do not provide a coherent, overall picture of what is being monitored, how the environment is changing over large spatial scales, or a clear sense of how the monitoring data might be used by resource managers and decision makers. The ability to provide coordinated and complete monitoring coverage is especially difficult because of the complex system structure, and the complexities of the associated physical, chemical, and ecological processes. These programs, however, provide information essential to our understanding and management of the system. These existing programs will figure prominently in the development of a CMARP.

### **Purpose of this report**

The CALFED Policy Group approved development of an CMARP in two stages. This report summarizes the work and recommendations of the Stage I effort. The report defines the relevant issues, the initial scope of effort, and presents proposed tasks and associated funds recommended for the completion of Stage II. Although the report primarily relies on ecosystem examples to emphasize and explain many of the relevant issues, the recommended program will ultimately address the monitoring, assessment, and research needs of all six CALFED common programs, as well as the monitoring needs of the Category III program, the conservation strategy, and any mitigation required through CALFED program implementation<sup>3</sup>. In addition, existing CALFED Agency needs will also be addressed in the recommended program.

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<sup>3</sup> It is expected that the Ecosystem Restoration Team (see Figure 2) will take the lead in addressing monitoring needs for the Conservation Strategy, as well as any mitigation required through CALFED program implementation.

The Stage I effort has largely been the work of a steering committee (referred to as the CMARP Steering Committee), consisting of representatives from the IEP, USGS, SFEI, and CALFED. This report and many of the concepts within the report have been discussed with and reviewed by several groups within the CALFED process (e.g., the Indicators Group, and the Ecosystem Roundtable), as well as groups existing within the CALFED agencies (e.g., the DWR Municipal Water Quality Investigations Program, and the IEP Science Advisory Group). In addition, CALFED staff, managers, and the CALFED Management Team have reviewed this report prior to submission to the CALFED Policy Group.

The goal of the Stage II effort is development of the initial CMARP. Stage II is proposed to be completed nine months after the Policy Group approves the Stage I study plan and allocates the necessary funding.

## Goals and Scope of a Comprehensive Monitoring Assessment And Research Program

### Overall Goals of the CMARP

***Monitoring and Assessment Program.*** The goals of the proposed monitoring and assessment program are to:

1. Provide information to management on a continuing basis necessary to evaluate the effectiveness of program actions, and to support ongoing adaptive management actions.
2. Describe conditions in the Bay/Delta, and its watershed on appropriate temporal and spatial scales. Determination of appropriate scales requires precise statements of management goals.
3. Evaluate trends in the measures of environmental condition.
4. Identify the major factors that might explain the observed trends.
5. Analyze data and report results to stakeholders and agencies on a timely basis.

***Research Program.*** The goals of the applied research program are to:

1. Build an understanding of physical, chemical, and biological processes in the Bay-Delta and its watershed that are relevant to CALFED program actions.

2. Provide information useful in evaluating the effectiveness of existing monitoring protocols and the appropriateness of monitoring attributes.
3. Test causal relationships among environmental variables identified in conceptual models\*.
4. Reduce areas of scientific uncertainty regarding management actions.
5. Incorporate relevant new information from academic research
6. Revise conceptual models as our understanding increases.

The scope of the CMARP will include all of the CALFED Bay/Delta Program elements (i.e., ecosystem restoration, water quality, watershed management, levee stability, water transfers, and water use efficiency), as well as the monitoring assessment and research needs of the CALFED member agencies. Such a broad scope will require an organizational structure that can ensure program implementation and quickly respond to necessary program changes. The recommended CMARP will include an organizational structure to ensure that monitoring assessment, and research needed by CALFED and CALFED agencies is: (1) identified, (2) coordinated to provide comprehensive system-wide coverage, (3) performed by the most appropriate party, (4) completed in a comparable manner by all parties, (5) accomplished with minimum redundancy and maximum effectiveness, and that the results from the monitoring are (6) interpreted, (7) made readily available to all interested parties and (8) incorporated as feedback to facilitate adaptive management.

### **Geographic Scope**

The geographic scope of the CMARP is dictated by attributes of the chemical, biological, and physical environment that fall within the CALFED solution area. For example, monitoring chinook salmon can necessitate some form of sampling from the headwaters, down the rivers, through the Bay/Delta and into the ocean. Conceptual models of the life histories of salmon (as for other species), will determine which of the almost limitless possibilities of physical, chemical, and biological attributes will be used to help set the geographic scope for monitoring the various attributes, and ultimately, the entire monitoring program. Monitoring associated with other program elements, such as water transfers, will also have wide program scope.

### **Programmatic Scope**

The scope of the recommended program must include both institutional and environmental considerations. For example, CALFED

agencies presently monitor the abundance of several key species and environmental attributes such as streamflow and fish salvage at the State and federal diversion facilities in the Delta. Although much of this monitoring occurs to address institutional needs, many of those needs are based on environmental considerations. Thus, the programmatic scope must consider the interplay between institutional and environmental considerations, and the resulting program must be able to respond to both considerations as they change over time.

***Institutional Considerations.*** The Stage II planning effort will include consideration of the specific needs of CALFED agencies as well as all of the elements of the CALFED Bay/Delta Program. From an agency perspective, the comprehensive program may include such disparate activities as real-time monitoring of fish distribution, compliance water quality monitoring, the Vernalis Adaptive Management Program, levee integrity evaluation, and a host of special monitoring and research related to each agency's mission.

For the CALFED Bay/Delta Program the planning effort will include the goals and objectives of the six common programs (ecosystem restoration, water quality, watershed management, levee stability, water transfers, and water use efficiency). CALFED management has determined that, monitoring, assessment, and applied research efforts are a critical component of the adaptive management process, and should be integral to each of the six program elements. It is recognized that the application of the program will be very different for levee and channel actions as opposed to water quality actions, for example. However, each program element has similar needs for assessment of results and gathering of the information that is necessary to that end. In addition, the CMARP must also address the monitoring and assessment needs of the CALFED conservation strategy, as well as any mitigation required as a result of CALFED program actions.

A special institutional case is the need for monitoring associated with Category III projects funded through CALFED. A requirement for Category III funding is that project proposals contain monitoring elements to determine if stated objectives have been met and to provide guidance for assessing future rehabilitation needs. It will be necessary for the recommended CMARP to ensure that monitoring data from all these projects are technically sound, broadly usable, and provide meaningful information to guide future actions.

***Environmental Considerations.*** The CMARP Plan will be designed to take into consideration the broad variety of factors that can affect the environment, its physical structure, chemical makeup and biotic communities. The recommended program will necessarily be limited to monitoring only a small fraction of the possible physical, chemical, and biological, attributes of the environment. Conceptual modeling, as described



more fully in a subsequent section, will play a key role in helping decide which attributes to monitor.

The following example shows how conceptual models can be used to objectively organize information necessary in the design of a monitoring program. A simplified listing of some of the factors that influence the abundance and distribution of a generalized Chinook salmon run (Figure 1) illustrates the ecological, geographical, and temporal scope which must be considered in developing a useful salmonid monitoring and research program (similar listings could be made for other species of interest). This listing points out that:

1. Monitoring physical, chemical, and biological indicators is necessary to develop a complete understanding of salmon ecology. Further, each factor listed, in turn, has an additional list of factors influencing it. For example, air temperature, reservoir operation, amount of riparian habitat, and stream-flow can all affect water temperature; food supply is influenced by streamflow, water temperature, riparian habitat (insect drop), contaminants, competition, and turbidity.
2. Broad geographic coverage is required - from the upper stream reaches to the ocean - in order to understand the run's life history, environmental requirements, and stressors. Further, in the early life stages, the relative importance of the factors listed in Figure 1 may be stream specific. That is, the effects of each factor will be considerably different on the mainstem Sacramento River as compared to streams like Mill and Deer creeks; and
3. Broad temporal range is needed because the time between egg deposition and adult return can vary from 2 to 6 years;

Although the example above focuses on a biological issue, many factors that may affect salmon also must be part of monitoring programs for other CALFED elements, including sediment transport, reservoir operations, water quality, water supply, levee condition and channel morphology. For example, monitoring sediment transport in the upper watershed provides information useful to determining potential areas of salmon spawning. Such information is also useful to documenting changes in channel morphology that may ultimately require human intervention. Thus, an integrated monitoring program should allow better overall management at lower cost.

The approach described in the salmon example could be applied to any issue identified for any of the six CALFED common programs. The development of simple conceptual models for a beneficial use of water, or seismic stability of delta levees, or a conjunctive use program within the San Joaquin River watershed will all help to identify the attributes necessary to monitor in each of these cases.

## **Approach to Preparing the Program**

The approach recommended for Stage II, is completion of a several specific tasks (described further below), involving the following activities:

1. Working with CALFED program managers, agency staff, and stakeholders, refine and clarify the overall goals and specific objectives of the CALFED programs in terms of monitoring, assessment, and research needs;
2. Based on present institutional knowledge, develop conceptual frameworks for understanding the factors controlling significant physical, chemical, and biological characteristics of the bay-delta and its watershed;

3. Design an integrated monitoring and assessment program. Development will include: an inventory of existing programs; methods and structure for integration and coordination of existing monitoring programs; identification of monitoring gaps; selection of monitoring elements; identification of a QA/QC program; development of a process for data management, analysis, interpretation, and reporting; and establishment of a process for monitoring approved Category III projects.
4. Identify primary research questions associated with CALFED program elements and develop a focused research program and review process.
5. Develop a recommended institutional structure necessary for effective implementation of the CMARP over the long-term.

It is expected that the recommended CMARP will incorporate many of the existing monitoring and research programs, provide a structure for the full integration of these existing programs, and provide a structure for the addition of new monitoring and research elements as program needs require. Accountability and efficiency are critical components of the overall program.

### **Stakeholder and Agency Staff Involvement**

Since much of the technical knowledge about the Bay/Delta and Central Valley system is in the minds, data files, and reports of many agency and stakeholder scientists and engineers, it is critical that they be involved in developing the CMARP. The Stage I effort has been coordinated with several other groups dealing with related topics and similar needs. For example, the CALFED Indicators Group is developing broad conceptual models and ecosystem indicators to guide implementation of the Ecosystem Restoration Program Plan (ERPP). The CMARP will include the development of more specific conceptual models consistent with broader models developed by the Indicators Group, and will ensure that the monitoring program includes critical ecosystem indicators identified by this group. Similar efforts have been initiated for the other five CALFED common programs.

At the beginning of Stage II, the Steering Committee will implement a structure for information flow that maximizes the involvement and interaction with agency staff, and stakeholder groups established for the six CALFED common programs. Figure 2 illustrates a likely arrangement for information flow. Stakeholders with a working knowledge of the existing monitoring programs will play a large role in the development of the Stage II. The most direct role includes participation with CALFED and agency staff in the Steering Committee and in technical work teams assembled to discuss

monitoring, assessment, and research needs of specific program elements. In addition, however, Steering Committee members will continue to:

1. actively interact with CALFED's Indicators Group, the Technical Coordinating Committee (formerly the Integration Panel), and other groups set up to work with CALFED staff in developing the common programs;
2. meet on a regular basis with the CALFED program managers to discuss monitoring and research needs for the six common programs, to identify connections among the programs, and to update the program managers on Stage II progress.
3. give presentations, as appropriate, to CALFED's Ecosystem Roundtable, Bay/Delta Advisory Council, and other established groups; and
4. work with representatives of major monitoring programs (such as those of the Regional Water Quality Control Boards, the Sacramento River Watershed Program, DWR's Municipal Water Quality Investigations Unit, the USGS, the VAMP technical team, watershed conservancies, the IEP Management Level Advisory Group, and similar organizations and units) to ensure the CMARP incorporates specific agency needs.

### **Need for Long-term Commitment**

As Stage II concludes, the collective efforts of the previous nine months will have resulted in the development of the first iteration of a CMARP. Articulation of program needs, identification of the key indicators, and the inventory of existing monitoring programs will guide development of this first version of the comprehensive monitoring assessment strategy. Identification of research requirements to support this initial monitoring strategy will also be an important work product. The steering committee intends to obtain an independent scientific review of the resulting CMARP as the first task subsequent to the completion of Stage II. The first iteration of a CMARP will serve as a baseline from which the CMARP will evolve. Results from the scientific review, refinement of conceptual models, and initial program information will all be used to refine the CMARP as implementation continues.

### **Recommended Stage II Program**

This section summarizes the structure and tasks recommended to develop an integrated monitoring assessment and research program for the Bay/Delta and its watershed. The core program includes five tasks to be completed over nine months at a cost of approximately \$1.8 million. The

details of each task are described below, and Figure 3 shows the timelines for all recommended tasks.

Stage II will be managed by a small Steering Committee consisting of CALFED and agency staff and stakeholders. With the exception of a representative from SFEL, Steering Committee members' salaries and expenses will be covered by their agencies or affiliations.

As illustrated in Figure 2, the Steering Committee will oversee completion of all recommended tasks. Participation on the Steering Committee will require a major commitment of participant time, and supporting organizations must agree to that commitment. It is expected that much of the work necessary to develop a CMARP will be completed by technical teams (and sub-teams for some programs) established to consider monitoring assessment, and research needs for each of the CALFED common programs. Participants on the technical teams will include individuals from the CALFED agencies, stakeholder organizations, and academic institutions as appropriate. In addition to the technical teams, two committees, a Data Management Committee, and a Data Analysis and Reporting Committee, will be established to lead completion of these key project elements. Finally, the Steering Committee will continually interact with CALFED program managers, and CALFED agency program managers. This interaction will occur through direct meetings, through individual assignments to various technical teams, and through completion of directed assignments.

### **Task 1- Refine Goals, Objectives, and Needs**

The fundamental mission of the CALFED Bay-Delta Program is to "... develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system." The specific objectives of this program, still under development, currently include the following four primary considerations:

1. to provide good water quality for all beneficial uses;

2. to improve and increase aquatic and terrestrial habitats and improve environmental functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species;
3. to reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system;
4. to reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.

Activities during Stage II will begin with a review of the established CALFED goals and objectives for all six common programs, and work with agency staff and stakeholders to identify CALFED agency goals and objectives for existing monitoring and research programs. Individuals assigned to this task will work to further refine these goals and objectives so they can direct the development of an CMARP.

The goal of any monitoring program is to produce information on the effectiveness of actions that is useful in making management decisions. This goal is enabled by ongoing two-way communication between scientists responsible for designing and implementing monitoring programs and the users of the monitoring information. Ensuring this communication occurs is a crucial task that will be addressed during Stage II. The CMARP Steering Committee will work with the CALFED program managers, agency staff, stakeholders, the scientific community, and the general public to further refine expectations and goals of the efforts to collect monitoring information, which will feed back to the development of the monitoring, assessment, and research strategies. The process for identifying the specific questions to be addressed by an CMARP would be achieved through the following activities:

1. Review information already collected during CALFED problem identification workshops, and in CALFED documents.
2. Review documents to be prepared by the CALFED program managers for each common program that provide detailed descriptions of the program monitoring and research needs as envisioned by CALFED staff and their respective stakeholders.
3. Identify goals and objectives for existing CALFED agency monitoring and research programs.
4. Review existing, relevant, peer-reviewed scientific literature to achieve an appropriate level of scientific understanding of the Bay-Delta and its watershed.

5. Consult with agency staff and stakeholders to specify the problems already identified and to define expectations and goals for information necessary to determine the state of each problem, in priority order;
6. Identify relevant laws, regulations, and permit requirements that include monitoring requirements;
7. Form a focused review group composed of stakeholders, CALFED program managers, and technical experts for facilitated discussions aimed at synthesizing information in items 1-5 to develop clear goals objectives, and needs for the CMARP.

This process, as with all components of the CMARP, will be iterative. It is expected that specification of goals and objectives will be sufficiently refined over the first three months of Stage II, although work to refine the program goals and objectives will likely continue throughout Stage II. The results of this task will serve as a foundation for all other work completed in Stage II.

Timeline:        One month: compile CALFED goals and objectives  
                       Three months: compile Agency major program goals and objectives  
                       Nine months: complete synthesis of goals and objectives

Funds:            \$ 25,000

Lead:             CALFED, EPA, and SFEI

## **Task 2 - Developing a Conceptual Framework**

The activities recommended under this task are intended to address the conceptual frameworks for all six CALFED common programs. The description that follows, however, focuses on the ecosystem restoration program, as an example of what this task is intended to achieve and how the activities would be accomplished. The ecosystem restoration program was chosen as the example, because of the large body of information that currently exists, and because CALFED has already devoted substantial effort to the development of a conceptual framework for the ecosystem restoration program.

Conceptual models are needed to incorporate current thinking by Bay-Delta scientists about how the ecosystem is structured and how it functions, about the effects of environmental stressors on relevant ecosystem processes, and about the effects of specific rehabilitation actions. The importance of conceptual models in ecosystem monitoring and assessment has been aptly described in a report issued by the National Research Council, *Managing Troubled Waters - The Role of Marine Environmental Monitoring* (National Academy Press 1990):

A description (i.e., a conceptual model) of the cause-effect links between human activity and anticipated environmental change is the central feature in developing specific questions to be answered [in a monitoring program]. It is the conceptual model that is the means of predicting environmental change and the results of management action – predictions that efficiently direct and focus monitoring efforts.

Conceptual models describe links among the resources at risk: the physical, chemical, and biological attributes of the ecosystem; and human and natural causes of change. The understanding that results permits testable questions to be clearly stated and ultimately evaluated. By providing a context for organizing existing scientific understanding, a conceptual model also identifies important sources of uncertainty.

Although many of the questions arising from a review of existing programs and CALFED documents were developed from implicit conceptual models of how the system works, many of these models need to be made explicit. Explicit conceptual models are not only useful in designing a future monitoring program, but are also useful to document the basis for earlier decisions about program design. Providing an objective basis through explicit conceptual models for both the design of a monitoring program and documentation of earlier decisions is a feature essential to development of an CMARP using an iterative approach.

The CALFED Indicators Group has undertaken construction of broad ecosystem models, based on the interconnections among the issues of water quality, hydrology, sediment supply, nutrients, and migrating species as they bear on habitats, ecosystem processes and interactions, and stressors.

The CMARP Steering Committee will work with the CALFED Indicators Group, the ERPP Strategic Plan core drafting team, and local academic and private sector experts to refine the broad models into appropriately detailed conceptual models to address the following objectives:



1. identify the highest priority issues to be addressed in the monitoring program (from system-wide and restoration-project-specific);
2. clarify both the goals and expectations of a monitoring program;
3. develop specific, testable questions for further research;
4. identify possible cause-effect relationships;
5. develop predictions i.e., how a particular environmental perturbation is expected to affect a monitored parameter and/or how a specific management action might affect an important resource; and
6. help identify gaps in knowledge where further research is needed.

During Stage II, the CMARP Steering Committee, in collaboration with the CALFED Indicators Group the ERPP Strategic Plan core drafting team, and CALFED program managers would accomplish the following as a start to the development of conceptual frameworks for CALFED's six common programs:

- A. Organize at least two workshops between April and June 1998 to summarize the status of Bay/Delta, and watershed conceptual modeling, including the work of the CALFED Indicators Group; to begin listing and prioritizing the major issues to be addressed in both system-wide and restoration-project-specific monitoring programs; to hear presentations from one or more experts about how monitoring, assessment, and research programs have been successfully developed elsewhere and how these programs have used conceptual models; and to develop recommendations about the next steps that should be taken in developing conceptual models that will facilitate achieving the CMARP goals and objectives. A written summary of the workshop proceedings and recommendations will be prepared and distributed for review by CALFED participants. A final report will be made available to all interested parties.

Timeline: Three months

Funds: \$10,000

Lead: DWR and USGS

- B. Organize several working panels of scientists to summarize our current understanding about the system and the effects of the six CALFED common programs. Work on this task will begin with the Ecosystem Restoration Program because it is further along in these efforts than the other five common programs. The working panels will focus on developing the conceptual model framework necessary to design effective monitoring programs and to identify data and

information gaps that need to be the focus of additional research efforts. The workshops may include both local and national scientists with experience in other systems, and scientists representing stakeholders. Each of these workshops would culminate in the preparation of a “white paper” discussing the state of knowledge in the workshop subject area, posing testable hypotheses and unanswered questions, and recommending appropriate strategies for both monitoring and research programs.

Timeline:        Six months

Funds:           \$300,000

Lead:             CMARP Steering Committee

- C.      Produce an overall report describing the conceptual framework of the CALFED six common programs upon which the CALFED monitoring, assessment, and performance measurement programs will be based. This report will include conceptual models, text to summarize the known structure and function of the ecosystem, description of scientific questions and hypotheses upon which monitoring and focused research will be based; and specific recommendations applicable to monitoring program design, such as identification of key parameters and functional linkages. The level of detail will vary among the six common programs, with the most detail expected for the conceptual framework associated with the Ecosystem Restoration Program Plan.

Timeline: Three months

Funds: \$50,000

Lead: CMARP Steering Committee

### **Task 3-Monitoring Program Design**

This section addresses two subjects. The first is initial development of a long-term CMARP, which is the major focus of Stage II. The second is the development of an institutional process designed to work in early implementation (1-3 years) specifically addressing Category III project monitoring.

Successful design of a long-term integrated monitoring assessment and research program depends upon identifying focused questions, which are based on clear statements of goals and objectives. Preliminary work, including definition of goals and objectives, conceptual model review, knowledge of existing programs and pilot monitoring are necessary to refine questions and technical aspects of monitoring designs. Some of this work (e.g. defining goals and objectives, conceptual model development) is described above in Tasks 1 and 2. The remaining work is described here.

#### **A. Inventory Existing Monitoring Programs**

This task will identify and assess existing monitoring programs in the Bay/Delta and its watershed. Monitoring needs determined through Tasks 1 and 2 can then be matched with efforts in existing monitoring programs to identify where integration of existing monitoring programs can fulfill current and future needs. In addition, this analysis will serve to identify redundancies, as well as gaps in monitoring where augmentation is needed.

This task will build on efforts conducted by CAMP, SFEI, and DWR's Municipal Water Quality Investigations program among others. The product will be a metadata information system providing program-specific information on program objectives, questions addressed through monitoring, spatial coverage, attributes monitored, location of sampling sites, frequency of monitoring, primary contact, reporting scheme, and funding. The system will be designed for continuous use for coordination, information on program status, and program gap analysis.

**Process:** SFEI will take the lead in development of the monitoring metadata system. Stakeholders, CALFED and CALFED agency staff will review a prototype design of the product and provide input as necessary until development is completed.

Timeline: Six months

Funds: \$250,000

Lead: SFEI

## B. Develop Monitoring Elements

The goal of this task is to narrow the focus of monitoring from the vast number of questions and parameters that could be examined to those that respond to the specific CALFED information needs. This task will run in conjunction with Tasks 1 and 2, addressing currently known needs of CALFED (as provided by descriptions of monitoring needs from CALFED program managers) and CALFED agencies. Additional information derived from Task 2 and the previous tasks (inventory of existing monitoring programs) will be used to subsequently modify monitoring elements to ensure their effectiveness.

Based on information obtained during Stage II, an integrated monitoring assessment and research program that focuses on CALFED's needs (ecosystem restoration, water quality, watershed management, levee stability, water transfers, water use efficiency, conservation strategy, Category III project monitoring, and mitigation monitoring) and CALFED agency needs will be developed. The strategy will be to identify current needs, identify and assess existing programs, and identify monitoring gaps. This information will be used to recommend modifications to the existing programs, to improve monitoring efficiency, and to fill the monitoring gaps. Quality assurance and control programs will be reviewed and a QA/QC element will be established to ensure consistent data collection and storage protocols. A process for linking individual databases will be described to facilitate comprehensive data assessment. The product will be a document identifying monitoring objectives, focused questions, specific monitoring elements to address the questions, and will include a recommended comprehensive monitoring and assessment program.

It is expected that many existing monitoring programs and elements will be recommended for integration into the proposed program. As mentioned previously, it is also expected that the level of detail for the recommended monitoring and assessment program will vary among the six common programs, due largely to the level of available information and the phasing of program implementation. For example, Stage II results will likely include a fairly detailed description of a recommended monitoring and assessment program for the Ecosystem Restoration Program. Whereas Stage II may

include only a series of recommendations for monitoring and assessment associated with the Water Transfers Program, ready for implementation once the program begins. The recommended monitoring and assessment program for the Levee Stability Program may be something in between.

**Process:** The CMARP Steering Committee will facilitate formation of technical work teams comprised of program managers of existing programs, agency staff, and stakeholders to: 1) determine program needs; 2) assess existing monitoring programs to increase efficiencies and reliability; 3) identify whether the needs can be met with existing monitoring programs, or if new programs are required; and 4) determine how best to coordinate the existing programs. Such a strategy has already been proposed for water quality monitoring (Inquiry Proposal for CALFED Category III funding) , by which IEP's water quality monitoring program, SFEI's Regional Monitoring Program, the Sacramento Watershed Program, DWR's Municipal Water Quality Program, the USGS' estuarine and river-basin monitoring program and the Central Valley and San Francisco Regional Boards water quality programs would be coordinated and augmented to meet CALFED's needs. The technical work teams would be responsible to the CMARP Steering Committee and all work would be reviewed periodically by a focused group of stakeholders, CALFED staff and agency staff. The CMARP Steering Committee will be responsible for organizing and collating all work into a useable product that will constitute recommendations for an integrated environmental monitoring program.

The monitoring program will be established to accommodate any compliance monitoring required as part of the conservation strategy or mitigation for CALFED actions and projects. For example, permits for a tidal marsh restoration project required as compensatory mitigation for CALFED actions may include specific monitoring and reporting requirements. Monitoring and reporting under the CMARP would be adjusted to fulfill these requirements.

Timeline: Nine months

Funds: \$415,000

Lead: CMARP Steering Committee and CALFED Agency  
Program Managers

#### C. Develop a process for data management

Data management is important to all aspects of the CMARP data collection and dissemination processes. Ultimately, the CMARP must make data/information readily accessible to CALFED Bay/Delta and agency staff and stakeholders. Data will also need to be updated regularly to meet the different program reporting time-lines in a way that allows information from one program to be related to another.

The purpose of an integrated database system is to allow for comprehensive, data management that permits broad access to biological, water quality, hydrodynamic, and physical data from the Bay/Delta and its watershed. The intent of the CMARP database project is not to duplicate or replace the efforts of any entity involved, but to provide a comprehensive, integrated source of data for scientists and decision-makers. Important features of such a database may include:

1. The data can be spatially referenced through a Geographic Information System.
2. The data base would include data from public agencies, municipalities, and larger private companies and consultants.
3. Simple queries may be conducted "on-the-fly" by scientists through menu-driven or graphical user interfaces, while more complex queries can be generated by each entity's database programmers.

The CMARP will ultimately include numerous data providers whose data management capability will vary substantially. A major cost of managing data from different groups will be developing a mechanism for obtaining or providing access to this data, in a standardized format, with adequate QA/QC and in time to meet program objectives. To manage this very large and diverse volume of information, a data management "infrastructure" will be recommended. This infrastructure will provide the ability for the data providers to manage their data locally, integrate data with other data collected in the system, and provide comprehensive access to all relevant data.

**Process:** A committee of technical experts (including agency staff and stakeholders) will review current data management systems, develop components necessary to provide the best system for managing data collected under an CMARP, and develop a prototype upon which to base a complete system. Specific tasks include:

- develop a list of data providers and their current information technology capability;
- determine the cost associated with obtaining and providing access to these data sources;
- determine how comprehensive access of existing data systems should occur;
- develop a process and estimate the cost for obtaining data from data providers;
- determine the cost of computer applications that are necessary to turn data into information; and

- evaluate GIS needs.

At the end of Stage II we will demonstrate an expandable system capable of managing data from a remote data provider where data management is conducted locally by the provider, but with ready data access by other parties. This access is essential to an integrated monitoring and assessment program consisting of a large number of separate entities.

Timeline: Nine months

Funds: \$100,000

Lead: CMARP Steering Committee and CALFED Agency Program Managers.

#### D. Develop a Process for Data assessment and Reporting

Technically sound, understandable reports released in a timely manner provide the all-important feedback about monitoring results to managers, regulators, and stakeholders. Appropriate interpretation and display must accompany monitoring data. Annual monitoring reports are envisioned, which include both data analyses and interpretive graphs and text.

**Process:** The Steering Committee will appoint a workgroup to design a decision support system\* that will integrate data collection, assessment, and reporting. The work group will assign a project leader to:

1. review information needs of CALFED program managers, agency staff, and stakeholders;
2. review decision support systems used in other locations such as Puget Sound, Chesapeake Bay, and South Florida;
3. hold one or more workshops with local and outside scientists and managers to synthesize the information gained from steps 1 and 2 above;
4. submit a recommended plan to the Steering committee; and
5. work with the CMARP Steering Committee to establish an outside scientific review panel to perform periodic review of the program.

Timeline: Within the nine-month period identified in Task 3B

Funds: \$100,000

Lead: CMARP Steering Committee and CALFED Agency Program Managers.

#### E. Category III Monitoring Institutional Process

A short-term institutional process is needed now to coordinate monitoring of approved Category III projects. To make Category III monitoring more effective, CALFED is awarding a grant to develop guidelines and protocols to ensure that:

- monitoring plans associated with Category III projects are sufficient to identify whether or not project goals and objectives are being met; and
- a process is established for the orderly flow of data collection to information from all Category III project monitoring to provide resource managers with information on individual project effectiveness and cumulative project impacts (both positive and negative).

**Process:** The Category III monitoring project began in Stage I with funding from a Category III grant to establish a dedicated chair/coordinator position. The chair is assembling a workgroup to review existing and proposed monitoring elements of Category III projects and develop recommendations for standardized monitoring protocols. The workgroup will also prepare recommendations for data management and information dissemination. Additional funding will be needed in Stage II to support the efforts of the workgroup throughout Stage II.

Timeline: Three months for process development

Funds: \$200,000 (not including the \$100,000 previously granted by CALFED).

Lead: CMARP Steering Committee and CALFED Category III Staff

### Task 4 - Design a CALFED Focused Research Program

This section describes the recommended approach for design of a focused research program and resumption of a research enhancement program. As previously stated, the goals of the focused research program are to reduce areas of scientific uncertainty affecting program actions, to identify cause and effect relationships, to corroborate relationships in conceptual models, and to provide information useful in evaluating the effectiveness of existing monitoring protocols and performance standards. The goal of the research enhancement program is to stimulate the involvement of the academic community in expanding our understanding of this complex



system. The process described hereafter would be used to implement both programs.

CALFED needs a focused research program to support staged implementation of the six common programs, and to investigate causes of trends detected in monitoring data. As suggested by the list of example uncertainties in Appendix D, the common programs face a number of unresolved questions that may reduce the effectiveness of large-scale actions. The list illustrates the breadth of uncertainties, many of which are not being addressed by current study programs. If uncertainties are left unresolved, some CALFED actions could lead to funding projects that do not achieve the desired benefits, or worse, cause irreversible environmental consequences.

The general approach would be to develop and maintain a list of study questions, to objectively select and fund a group of focused research projects, and annually to evaluate and present new study findings to CALFED agencies and stakeholders. During Stage II a focused research program would be developed by involving the CMARP Steering Committee with the technical teams described in Task 3. The proposed design would be subjected to the normal CALFED approval process and summarized in a report during Stage II. The initial list of study questions would come primarily from:

- an assessment of management questions and study needs of CALFED's six common programs completed by the technical teams and facilitated by CMARP staff;
- the results of the 1997 Category III RFP process, which identified several information gaps;
- gap in knowledge identified in the conceptual models completed through Task 2; and
- the body of scientific literature on the estuary and its watershed (such as the technical report series of IEP, the Status and Trends reports of the San Francisco Estuary Project, the USGS bibliography of publications for the bay and delta, the State of the Estuary conference proceedings, and the SFEI Regional Monitoring Program annual reports).

The final list of study questions would address the most serious uncertainties related to implementing CALFED program elements. The list of questions would serve as the basis for soliciting proposals from the scientific community. During Stage II a proposal review and approval process will be designed that includes:

1. an anonymous peer review process;

2. a technical review panel composed of agency staff and stakeholders;
3. review by the CALFED integration panel; and
4. review and approval by the BDAC, CALFED Management Team, and the CALFED Policy Group.

In addition to integrating the research findings into the CMARP decision support system, an annual evaluation and presentation of new study findings could occur through:

- an annual presentation of progress by principal investigators of funded proposals at a CALFED science conference each September;
- presentations at the IEP annual conference in February; and
- technical reports and peer reviewed literature.

**Research enhancement program.** This program was begun by EPA's San Francisco Estuary Project and IEP about ten years ago. The program funded about 20 graduate students to work on problems judged relevant to the management problems of the bay-delta estuary. Although this program was less directed at management questions than the focused research program will be, it generated many worthwhile findings before it was discontinued for lack of funding. Given availability of CALFED funds, the CMARP Steering Committee would perform necessary staff work to resume this program with an appropriately expanded geographical extent and problem scope.

**Stage II activities.** The CMARP Steering Committee would undertake and/or oversee completion of the following tasks during the nine months of Stage II:

- A. A preliminary assessment of CALFED needs would be performed for each of the common programs. Program documents would be reviewed and program managers would be queried about the actions proposed and management questions associated with each program. Based on these queries and on the existing literature, a preliminary list of management and study questions would be created. This preliminary list would serve as a starting point for deliberations within the appropriate technical team. The lists emerging from the technical teams would then be submitted for review and approval through the usual CALFED process.

Timeline: Six months

Budget: \$200,000

Lead: CMARP Steering Committee

- B. One or more requests for proposals (RFPs) would be designed to solicit proposals for addressing the identified study questions. Similarly, the brochure for the research enhancement program would be revised to address CALFED's geographic extent and problem scope. These documents would be submitted to the CALFED approval process, as done for Category III RFPs.

Timeline: Three months

Budget: \$25,000

Lead: CMARP Steering Committee

- C. An anonymous peer review process, similar to that used by the National Science Foundation, would be designed to judge the technical merit and relevancy of the proposals, and to provide these

results to the CALFED integration panel via an in-house technical review panel. A process for the identification and compensation of reviewers would be designed in consultation with appropriate academic institutions.

Timeline: Three months

Budget: \$25,000

Lead: CMARP Steering Committee

- D. An agenda for a first CALFED science conference would be devised, session chairs would be selected, and a preliminary program of invited presentations would be developed. The focus of the initial conference would be the state of scientific knowledge in the areas pertinent to CALFED's proposed actions, and presentations of early results of research projects funded with Category III funding. This draft program would be submitted for CALFED approval and funding. If approved, the conference would be held in 1999, and would be timed to coincide with release of the first RFPs.

Timeline: Three months

Budget: \$25,000

Lead: CMARP Steering Committee

- E. Results of these four tasks would be summarized in a report or in a section of the CMARP Stage II report.

Timeline: Three months

Budget: \$25,000

Lead: CMARP Steering Committee

### **Task 5-Develop an Institutional Structure for the CMARP**

An extraordinary amount of coordination, collaboration and integration will be required for effective implementation of a system-wide CMARP that meets the needs of CALFED and other resource management mandates of the CALFED agencies. Much of the monitoring required to fulfill the adaptive management needs of CALFED is already in place. Adjustments or expansions to existing programs will be needed, and for some common programs, new monitoring programs will be recommended. Because of the size of the system and the large number of monitoring programs already in existence, numerous agencies at the federal, state, regional and local levels,

academic institutions, non-governmental organizations, and stakeholders will need to be involved.

It is unlikely that any one organization can implement an CMARP over the entire Bay/Delta watershed and its water management infrastructure. What may come of this planning process instead, is an 'umbrella' structure that would draw substantially on existing monitoring programs under numerous agencies and organizations, and assist those agencies and organizations in filling the gaps identified in the current system. The goal of this umbrella structure would be to ensure that an integrated program emerged from a myriad of inter-organizational coordination and collaboration efforts, that information for decision-making was reported from these programs in a timely manner, and that this information was clearly communicated to decision-makers and the public. The umbrella structure must, however, provide assurance that the needed monitoring and research will be completed.

During Stage II, the CMARP Steering Committee will develop recommendations for creating an institutional structure to implement the CMARP over the long-term. Because the actual program configuration will continue to evolve over the next several years, an emphasis will be placed on flexibility, insuring that new players can become fully involved as needed, and additional monitoring and research questions can be addressed as they are identified. The committee recommendations will be developed after examining the strengths and weakness of current cooperative working relationships, considering the information needs of the CALFED participating agencies, consulting with organizations that will be involved as partners in the CMARP, and consulting with stakeholders.

Timeline: Six months

Budget: \$50,000

Lead: CMARP Steering Committee

**Figure 1. Listing of Some Factors Influencing Distribution and Abundance of Generalized Central Valley Chinook Salmon Stock**

Life Stage	Factors		
Spawning/egg deposit	Barriers and effects of delays		Water temperature
	Flow (stability and rate)		Predation on adults and eggs
Incubation	Gravel permeability		Flow
	Water temperature		Dissolved oxygen
	Sediment/turbidity		Contaminants
	Egg quality		Disease
Early Rearing	Water temperature		
	Food supply (amount and quality)		
	Diversions		
	Availability of escape habitat		
	Competition and compensatory mechanism		
	Rearing location (in-river/estuary)		
Active Migration to Ocean	Fishing	Predation	Contaminants
	Diversions	Competition	Disease
	Water temperature	Barriers	Streamflow
	Delta hydraulics		
Ocean Rearing	Food	Water temperature	El Nino/La Nina
	Harvest	Predation	Disease/parasites
Return to Freshwater	Food reserves	Harvest	Barriers
	Availability of migratory areas		Streamflow

**Insert Figure 2, Proposed Stage II Organizational Structure**

**Insert Figure 3, Timeline**



## Appendix A

### Glossary of Specific Terms Used in this Report

***Adaptive management:*** Adaptive management consists of undertaking an action (or set of actions), evaluating effectiveness of achieving the goal, modifying the action if it is not achieving its intended results and to plan to use the information from early efforts to guide later efforts. Adaptive management presupposes goals, competing theories about the most effective way to achieve the goals, and a monitoring or research program that identifies changes to the environment and the response of the intended target.

***Conceptual models:*** Explicit statements of the hypothesized functional relationships underlying management decisions regarding environmental resources. Conceptual models are essential tools for effective monitoring, research, and management because they highlight the significant environmental parameters, important data gaps, and the expected linkages among actions and effects. Conceptual models vary greatly in their level of specificity and complexity.

***Decision Support System.*** A formalized process for the flow of information necessary to make decisions. The overall system should provide information feedback loops at critical stages of the decision making process. Provides for objective, informed decision making.

***Monitoring:*** Development of information from data sets that report the distribution, condition, abundance or other aspects descriptive of status and trends of environmental features of interest. Monitoring includes, for example, standardized biological surveys, water chemistry, measurements of river flows, and assessment of levees for compliance with federal standards.

***Research:*** Data collection, analysis, and interpretation intended to test hypotheses about functional relationships among environmental parameters. Research includes studies of the relations among uncontrolled variables as well as experimental manipulations of environmental variables.

## **Appendix B**

This appendix includes copies of the memoranda describing the initial CMARP development proposal and subsequent approval.

Letter to Lester Snow, Page 1

Letter to Lester Snow, Page 2

Letter to Lester Snow, Page 3

Letter from Lester Snow, one page

## Appendix C

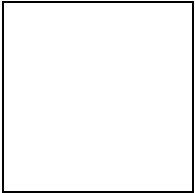
### Initial Summary of Existing Monitoring and Research Programs

Information about several existing monitoring and applied research programs was gathered through literature searches and direct contact with the organizations or program leaders. The summary information is displayed in a metadata format that may be used in Stage II, Task 3. A table at the end of the summary shows overall budget information for the programs

This summary shows that over \$22 million a year is currently spent on monitoring and applied research in the Bay/Delta and Central Valley. Although the list includes some of the largest programs, many other programs exist in the area. For example, USBR (in conjunction with other federal, state and local agencies) conducts the Grassland Bypass Project adjacent to the San Joaquin River, south of Oristamba Creek. This program monitors flow, water quality, sediment, and biological factors. Local colleges and universities conduct research on a variety of topics in the Bay/Delta, however, information regarding these studies was not pursued for this summary.

It is important to note that IEP and CAMP are listed as individual monitoring programs. However, both are representative of numerous projects within the Bay/Delta and Central Valley. Summary information about the individual programs under CAMP was published in March 1997, in the U.S. Fish and Wildlife Service's CAMP implementation plan. This document lists metadata summaries of the existing adult and juvenile monitoring programs in the Central Valley, in a format suitable for use in a Geographic Information System (GIS).

Two additional sources for information on existing monitoring programs are DWR's Compendium of Water Quality Investigations and SFEI's coastal water quality monitoring program inventory. The compendium covers the Sacramento River watershed from the Bay/Delta region to the Oregon border and will be published in April 1998. Each sampling site is mapped and has corresponding metadata summaries gathered from surveys of federal, state and local agencies. This project is a good source of information, particularly about the smaller, local water quality monitoring programs. Funds have been designated to expand this program to the San Joaquin River watershed. SFEI's coastal inventory work will include metadata summaries on permit water quality programs and should be finished by mid-summer 1998.





**Agency:** Interagency Ecological Program (IEP)

**Program Contact:** Chuck Armor  
**Address:** Department of Fish and Game, Bay Delta Division  
 4001 North Wilson Way  
 Stockton, CA 95205  
**Phone:** (209) 948-7800  
 (209) 946-6355 fax  
 carmor@delta.dfg.ca.gov

**Program Objectives:**

- To provide for the collection and analysis of data needed to understand and manage the Sacramento-San Joaquin estuary controlling the distribution and abundance of wildlife resources and make the data readily available to other agencies and
- To comply with permit terms requiring ecological monitoring in the estuary
- To identify impacts of human activities on the fish and wildlife resources.
- To interpret information produced by the program and from other sources possible, recommend measures to avoid and/or offset adverse impacts of operation and other human activities on these resources. To seek consensus recommendations, but to report differing recommendations when consensus is not possible.
- To provide an organizational structure and program resources to assist in planning and integration of estuarine studies by other units of cooperating agencies

**Start Date:** IEP formed in 1972. Inception date of individual programs varies

**Attributes Measured:**

1. Hydrodynamics
2. Water quality
3. Lower trophic organisms (e.g. zooplankton, phytoplankton)
4. Fish & macroinvertebrates

**General Area:** Between and including San Pablo Bay and the Delta

**Number of Sampling Sites:** Numerous

**Frequency:** Hydrodynamics: continuous  
 Water quality: both continuous and discrete monthly measurements  
 Lower trophic organisms: both continuous chlorophyll sampling and discrete zooplankton sampling.  
 Fish and macroinvertebrates: varies between bimonthly sampling and annual collection.

**Budget:** Monitoring: \$4.9 million  
 Special Studies: \$6.3 million  
 Program Management: \$1.5 million

**Agency:** Sacramento River Watershed Program

**Program Contact:** Tom Grovhoug  
Larry Walker Associates

**Address:** 509 Fourth Street  
Davis, CA 95616

**Phone:** (916) 753-6400  
(916) 753-7030 fax  
lwa@davis.com

**Program Objectives:**

- To ensure that current and potential uses of the watershed's resources are sustained and, where possible, enhanced while promoting the long-term social and economic development of the region.
- In coordination with other subcommittees and the larger stakeholder group, develop an efficient and well-coordinated long term monitoring program within the watershed to identify the causes, effects and extent of constituents of concern that affect the beneficial uses of the river and to measure progress as control strategies are implemented.
- To assess conditions in the main stem of the Sacramento River through the monitoring program, with an emphasis on examining the degree to which beneficial uses are potentially impaired.

**Start Date:** Spring 1998 (some elements began in 1997)

**Attributes Measured:**

- Mercury, PCB's and chlorinated pesticides in fish tissue
- Trace metals in water (arsenic, cadmium, copper, chromium, lead, mercury, silver and zinc)
- Aquatic life toxicity in water and sediment
- Pathogens in water (*Cryptosporidium*, *Giardia*, coliforms)
- Organic carbon in water
- General constituents (minerals, nutrients, solids, turbidity, hardness) in water
- Benthic invertebrates
- Algae (attached and planktonic)

**General Area:** Sacramento River watershed from above Shasta dam to near Folsom, including several major tributaries.

**Number of Sampling Sites:** 63 total sites; number varies according to attributes measured

**Frequency:** Basic chemical characteristics: varies between monthly and semi-annually  
Pathogens: varies between monthly and quarterly  
Chronic aquatic toxicity in water: varies between monthly and quarterly  
Sediment toxicity: twice annually  
Fish tissue analysis: once annually

**Budget:** Monitoring: \$500,000 for the first year.  
Other: \$500,000

**Agency:** Department of Water Resources  
Municipal Water Quality Investigations Program

**Program Contact:** Rich Breuer  
**Address:** 1020 9<sup>th</sup> Street, 3<sup>rd</sup> Floor  
Sacramento, CA 95814  
**Phone:** (916) 327-1726  
(916) 227-1648 Fax  
rich@water.ca.gov

**Program Objectives:**

1. To determine and evaluate the source of contaminants that affect the quality of the Sacramento – San Joaquin Delta
2. Alert water agencies about current and potential contaminants in Delta
3. Assist water supply agencies in planning, protecting, and improving drinking water and water supply facilities
4. Document water quality under a variety of hydrologic conditions for several alternatives, water quality standards and predictive modeling capabilities

**Start Date:** 1983

**Attributes Measured:**

Varies by site; includes: Standard mineral, turbidity, UVA, TOC, DOC, Bromine, THMFP, reactivity-based THMFP and HAAFP, Ammonia, MTBE.

**General Area:** Delta

**Number of Sampling Sites:** 13 (varies yearly)

**Frequency:** Varies between weekly and monthly measurements

**Budget:** Monitoring: \$350,000  
Applied Research: \$1,175,000  
Other: \$225,000 (Program Management)

**Agency:** Comprehensive Assessment and Monitoring Program (CAMP)

**Program Contact:** Larry Puckett  
**Address:** U.S. Fish and Wildlife Service  
 3310 El Camino Avenue  
 Sacramento, CA 95821  
**Phone:** (916) 979-2760  
 (916) 979-2770 fax  
 larry\_puckett@fws.gov

**Program Objectives:**

1. To assess the **overall** (cumulative) effectiveness of actions implemented p Section 3406(b) in meeting AFRP production targets and
2. To assess the **relative** effectiveness of categories of Section 3406(b) action management modifications, structural modifications, habitat restoration, a toward meeting AFRP production targets.

**Start Date:** CAMP was developed in 1997. Inception date of individual prog began in 1952).

**Attributes Measured:**

Varies according to program. Juvenile and adult surveys of Chinook salmon, st bass, white sturgeon, green sturgeon and American shad. Monitoring includes: spatial and temporal spawning distribution, length frequency, sex ratio, fish ma clarity and water temperature. Ladder counts, snorkel surveys and carcass surve

**General Area:** Central valley watersheds

**Number of Sampling Sites:** Numerous

**Frequency:** Varies according to program from daily (continuous) to annua

**Budget:** \$2.5 million  
 The \$2.5 million budget shown for CAMP reflects the amount monitoring, either for new monitoring programs or to subsidi  
 The total budget, which now stands at about \$5 million, includ agencies pay and can fluctuate greatly from year to year with tl short-term monitoring projects

**Funding summary for several existing monitoring and applied research**

<b>Organization</b>	<b>Monitoring</b>	<b>Applied Research</b>	<b>Other*</b>
San Francisco Estuary Institute (SFEI)	\$2.5 Million	\$1.5 Million	\$388,000
Interagency Ecological Program (IEP)	\$4.9 Million	\$6.3 Million	\$1.5 Million
Comprehensive Assessment and Monitoring Program (CAMP)	\$2.4 Million	\$0	\$132,000
Sacramento River Watershed Program (SRWP)	\$0.5 Million	\$0	\$0.5 Million
Municipal Water Quality Investigations Program (MWQIP)	\$0.4 Million	\$1.2 Million	\$0.3 Million
<b>Total</b>	<b>\$10.7 Million</b>	<b>\$9 Million</b>	<b>\$2.8 Million</b>

\*Note: "Other" includes administrative costs, quality assurance/control, coordination of monitoring and stakeholder activities

## Appendix D

### Examples of CALFED management uncertainties.

1. **Wetland restoration.** Significant amounts of the land in the delta have subsided by more than 10 feet below sea level, with some islands as much 25 feet below sea level. Restoring these subsided peat islands poses a particular challenge to wetland restoration efforts in the delta.
  - Restoring land-surface elevation of subsided lands is a necessary step for developing tidal aquatic habitat. Options for accreting land surface (e.g. application of dredge material, biomass accretion, suspended sediment deposition) all have serious limitations to overcome to accomplish this task in a reasonable period of time.
  - Delta channel waters currently form high levels of disinfection by-product (DBP) carcinogens from DOC when treated for use as drinking water. Peat soils in the delta are currently thought to be the largest source of DOC in delta channel waters. All CALFED alternatives include a substantial continuing contribution of delta channel water to the California drinking-water supply. Wetland restoration on peat soils may increase the DOC released to the delta channel waters and thus the DBP carcinogens in drinking water.
2. **Introduced species.** The role of introduced species as contributors to the ecological problems in the estuary is not well understood. In particular, the degree to which habitat restoration will encourage exploitation by exotic species that might prey on or compete with species of concern is not known. Thus, pilot restoration projects are needed to carefully monitor species-habitat relationships before large-scale restoration is undertaken.
3. **Contaminant effects.** The role of contaminants as contributors to the environmental problems of the delta and bay is not well understood. If a monitoring program is to assess the effects of habitat restoration on population changes, the deleterious effects of contaminants at least need to be ruled out:
  - More than 200 pesticide compounds (10% of total U. S. usage by weight) are used in the Central Valley. During winter runoff events insecticide concentrations in the Sacramento and San Joaquin Rivers, the Delta, and Suisun Bay have been shown to be acutely toxic in standard bioassays of test organisms. Effects of pesticides on resident organisms need to be assessed.

- Limited data suggest that methyl mercury is already contaminating several species in the Bay-Delta (sturgeon, striped bass, sharks). Many of the areas being considered for wetland restoration contain hydraulic mining debris deposited during the late 1800s. Methylation of the mercury contained in these sediments may significantly increase the contamination problem.
  - A high probability exists that selenium is affecting diving ducks and sturgeon, and perhaps other bottom-feeders such as dungeness crab. Changes in water conveyance could increase the amount of San Joaquin River water and selenium that enters the estuary. Documenting current conditions is a necessary step in evaluating the effects of CALFED actions.
4. **Delta hydrodynamics.** A hydrodynamic model that is validated with continuous flow data is needed to evaluate the effects of CALFED actions on flow and water quality in the delta. A primary missing component for such a model to be successfully applied is adequate channel bathymetry data in portions of the delta.
  5. **Levee stability.** More than 1000 miles of levees in the delta are made of poor quality materials, and surround more than 500,000 acres of farmland that continue to subside at a rate of 2 to 4 inches per year. Early estimates of the potential costs of delta levee rehabilitation exceed \$2 billion. Given that phasing of repairs will be necessary, additional characterizations of levee stability are needed to set priorities for rehabilitation. For instance, collection and analysis of ground motion potential data that ranks levee seismic vulnerability are needed.
  6. **Land subsidence potential.** Proposed increased conjunctive use of surface and ground water in the Central Valley lacks an adequate recognition of the potential for renewed land subsidence and aquifer destruction. A well monitoring program and groundwater model of the Central Valley has yet to be constructed that incorporates aquifer properties needed to assess subsidence potential. In addition, no program presently exists to develop tools to optimize conjunctive use while avoiding subsidence and water-quality problems.

## Appendix E

### Response to Comments

This appendix includes select comments received from the review of public drafts of this report. Numerous comments were received, and most comments resulted in one or more editorial or substantive changes to the report. Comments that **did not** result in a change to the report are listed below followed by a response from the CMARP Steering Committee.

Comment: Jim Cloern, USGS and IEP Scientific Advisory Group. The deadlines that have been set for development of Stage II are, however, unrealistic; these deadlines underestimate the complexity of what is being proposed and will make it difficult to achieve the full potential of the effort.

Response: The CMARP Steering Committee received several comments regarding the length of time allotted to Stage II and specific tasks within Stage II. The Steering Committee recognizes the time constraints imposed on Stage II are particularly challenging. In particular, the Stage I report includes a section entitled, Need for Long-term Commitment. This section acknowledges that the collective efforts of Stage II will result in the development of the first iteration of an CMARP. Refinement of the goals and objectives, continuation of the work to develop a conceptual framework, and results from the initial CMARP will all be used to modify and refine the CMARP. The Steering Committee has also revised the Stage II task descriptions to more realistically reflect what can be accomplished over nine months. However, the Steering Committee chose not to extend the Stage II timeline due to the anticipated dates for the completion of other associated CALFED work (e.g., the complete CALFED EIR/S is due November, 1998), and due to the expectations of Interior Secretary, Bruce Babbitt and congress.

Comment: Jim Cloern, USGS and IEP Scientific Advisory Group. The plan, in general, gives the perception of underestimating the challenge and the value of improving our detailed knowledge of watershed/estuarine/biological processes that are relevant to management and monitoring in the Bay-Delta. Correction of this perception is critical to a successful rehabilitation.

Response: The Stage I report probably does give the perception of underestimating the challenge of developing an integrated environmental monitoring and research program. This likely occurs for two reasons: 1) keeping the report as short and focused as possible was a high priority; and 2) the purpose of the report is to propose a strategy for addressing this



challenge. The Steering Committee does recognize the challenge of this undertaking and is developing a process to resolve the uncertainty.

In contrast, the report does discuss in some detail the value of improving our detailed knowledge of the system. The need for such knowledge and for increasing coordination and communication is discussed at several points throughout the report.

Comment: Jim Cloern, USGS, IEP Scientific Advisory Group. As SFEI works on Task 3 (design of a comprehensive monitoring program), I hope they will start from the solid foundation that already exists. Considerable effort has been made by others to conceive the principles of a bay-wide comprehensive monitoring program. In particular, I hope SFEI starts with the consensus recommendations and guidelines that came from the August 1996 workshop organized by Pat Coulston (of course this means that IEP has to release and distribute the report from that workshop first.)

Response: Completion of Task 3 will involve many other entities and groups in addition to SFEI. Clearly, it is in the best interest of all parties to use the “solid foundation [of information and work] that already exists” in completing Task 3. No one working on Stage II wants to spend time “reinventing the wheel.” The timeline does not allow this. The SFEI, and others on the steering committee, are aware of the 1996 workshop on comprehensive monitoring organized by Pat Coulston. In fact, Bruce Thompson of SFEI participated in that workshop. A final version of the report is being prepared, but Pat Coulston’s departure from IEP has delayed completion of this report.

Comment: Sam Luoma, USGS and IEP Science Advisory Group. USGS has spent years trying to develop a data management system for NAWQA. SFEI tried to do this for the Bay and, essentially failed. This is hard... it only gives the poorly informed a false impression to pretend that it can be done in nine months.

Response: You may be referring to the unsuccessful effort of the former Aquatic Habitat Institute to serve as a clearinghouse for all data collected in the estuary by all agencies. The Steering Committee is well aware of the difficulties in developing a comprehensive data management system. However, the Stage I report does not propose to develop and implement a complete data management system over nine months. Specifically, it is recommended that “A committee of technical experts, managers and stakeholders meet to review current data management systems, develop the components necessary to provide the best system for managing CMARP data, and develop a prototype upon which to base a complete system.” The

IEP has developed a comprehensive relational data base that makes data from a variety of sources generally available through a single conduit. Although this system is still under development, initial feedback has been positive.

Comment: Sam Luoma, USGS and IEP Science Advisory Group. A renewed REP and a proposal selection process will require staff to run. To maintain continuity and credibility the staff should be informed, have some permanence, and it should be a principal assignment. I suggest a private sector entity be contracted to manage these programs, and an adequate budget be designated up front. This is a big job.

Response: This may be so. The Steering Committee expects to address this issue in detail during Stage II.

Comment: Phil Wendt, DWR Water Quality Assessment Branch. I also have concerns about allocating funds to SFEI to develop an inventory of monitoring programs. Especially one that adequately represents drinking water quality programs, as well as levees, watershed management, water transfers, etc. I believe it may be premature to assign responsibility, and funds, for such an important component of the plan, without a broader review by other stakeholders.

Response: Although listed as the lead on this task, SFEI will be working with a variety of organizations and individuals to complete the inventory of existing programs. SFEI has the expertise to coordinate such a task, and no stakeholders reviewing this document have expressed this concern. This task is mainly seen as a compilation of existing information, such as the work your staff recently completed to inventory existing water quality programs in the northern portion of California.

Comment: Phil Wendt, DWR Water Quality Assessment Branch. It is also unclear as to how funds are prioritized and dispersed to cooperating entities.

Response: At the release of the Stage I draft report the steering committee was still working to develop a detailed strategy for the disbursement of funds, both to the core group and cooperating entities. The final report includes a more detailed description of this. Contracting requirements will all necessitate preparation of more detailed fund expenditure tables. We do not anticipate prioritizing the funds necessary to complete Stage II. Once the funding level has been approved all funds would be dispersed as required to ensure completion of all Stage II tasks.

Comment: Phil Wendt, DWR Water Quality Assessment Branch. Page 19 – Unclear whether you are proposing a new, separate data management system, or a series of linked databases with an agreed upon data format for access and reliability. IEP, CUWA, and others already have comprehensive data projects in the works.

Response: Such decisions are beyond the scope of the Stage I report. A technical team will be put together to address this issue during Stage II. You are encouraged to participate. A recommendation for a data management system is the result of Task 3.D.

Comment: Doug Morrison, U.S. Fish and Wildlife Service. Need for Mathematical Modeling Element: Predictive simulation models. The report should better describe the role of mathematical predictive, simulation models in CMARP and the overall scientific approach supporting CALFED programs (These types of models are mentioned only in Appendix C). The definition of research in Appendix A should include predictive simulation modeling; or perhaps more appropriate, modeling (mathematical predictive simulation) should be a separate element, along with monitoring and focused research. Mathematical predictive, simulation models, along with focused research and monitoring, are essential elements of science programs supporting large-scale ecosystem restoration and management programs (e.g., south Florida, Chesapeake Bay, Mississippi River Delta). Predictive simulation models would contribute to many of the CMARP goals (p. 4) including evaluating and predicting environmental trends (including responses to management actions), provide information on the effectiveness of management actions, and reduce scientific uncertainty regarding management actions. These models could include landscape, hydrologic and hydrodynamic, population, water quality, and contaminant fate, transport, and risk assessment models.

Response: Although the steering committee recognizes the utility of models and the resulting information, models are viewed as one of many tools used in research. Modeling (especially hydraulic models and models of conservative properties) already has a strong role in improving our understanding of the Bay-Delta and its watershed. We do not agree that modeling should be identified as a separate element in the Stage I report along with monitoring and research.

Comment: Doug Morrison, U.S. Fish and Wildlife Service. Institutional Structure for the CMARP. I propose for Stage II and especially beyond that the CMARP Steering Committee include a representative from each

CALFED agency (Similar to CALFED Program Coordination Team [PCT]). These representatives would function in part as agency liaisons. The roles of the Steering Committee would include CMARP coordination and oversight and facilitating CALFED agencies support, participation, and communication. Leads of this Steering Committee would be USGS, IEP state and federal lead agencies, and SFEI. The current Steering Committee would be a subcommittee of the proposed broader Steering Committee but with still the primary role of developing CMARP Stage II. The overall committee could assist the subcommittee by, for examples, organizing the workshops and facilitating CALFED agency involvement. Forming a BDAC science advisory committee for stakeholder input to CMARP is a very good idea (This approach has proven effective in the South Florida Ecosystem Restoration Program). Adding representative stakeholders to the proposed steering committee might also be considered.

Response: A variant on what you suggest is the organization proposed during the completion of Stage II. Task 5 of the Stage I report is intended to specifically address this issue beyond Stage II. You have suggested one possible structure, which will be considered further during completion of Task 5. You have obviously done some thinking about this issue, and we encourage your active participation during the completion of Stage II.

Comment: Doug Morrison, U.S. Fish and Wildlife Service. An independent scientific panel should conduct periodic reviews at important milestones in the program throughout the three-year period, not just at the end of the period (p. 9, last sentence).

Response: This is highly possible. Although the Stage I report suggests a comprehensive program review at the end of three years, more frequent reviews may be appropriate. We expect to revisit this issue in more detail during the completion of Stage II.